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1971 SURVEY AND ASSESSMENT OF AIR POLLUTION DAMAGE TO VEGETATION IN NEW JERSEY

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A survey of injury resulting from air pollution episodes and assessment of their resultant effect on crop production in 1971 was conducted in New Jersey. Economic loss to crops due to air pollution was estimated at 1,183,800. The survey did not include: indirect losses such as growers' relocation cost, crop substitution losses, nor economic losses to forest trees and ornamental plants and reduction in crop yield due to invisible injury. Three hundred fifteen reported air pollution incidences were investigated and documented during the period of this survey. Plant injury was observed in 17 counties but economic loss or crop damage was observed in only 16 of these counties. Only 29 out of the seventy plant species that exhibited injury were involved in the assessment of crop loss. As a group, vegetables accounted for 51 percent ($598,099) of the total crop loss. The photochemical pollutants were responsible for 80 percent of the plant injury recorded, with ozone contributing about 60 percent and PAN 20 percent of the total. Other pollutants involved were HCl mist, chlorine gas, ethylene, fluoride, sulfur dioxide, ammonia, particulates, oil, and petroleum.

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1971 Survey And Assessment Of Air Pollution Damage To Vegetation In New Jersey

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October 1972

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Appreciation is also expressed to those members of the New Jersey Department of Agriculture, Division of Plant Industry who participated in the survey on nurseries, and to the New Jersey Crop Reporting Service for providing the necessary information needed in the assessment of crop losses. The cooperation of the Department of Meteorology of Rutgers - The State University in providing weather reports pertinent to possible air pollution episodes is gratefully acknowledged.

ABSTRACT

A survey of injury resulting from air pollution episodes and assessment of their resultant effect on crop production in 1971 was conducted in New Jersey with the assistance of the Cooperative Extension Service and the Department of Plant Biology of Rutgers University. This survey was concentrated in the central and southern counties of the state where most of the agricultural crops are grown.

Economic loss to crops due to air pollution was estimated at $1,183,800. Indirect losses such as growers' relocation cost, crop substitution losses and loss in value of the land were not included. Likewise, economic losses to forest trees and other ornamental plants and reduction in crop yield due to invisible injury were not included.

Three hundred fifteen reported air pollution incidences were investigated and documented during the period of this survey. Plant injury was observed in 17 counties but economic loss or crop damage was observed in only 16 of these counties. Over one-fourth ($337,265) of the total crop losses for New Jersey were recorded in Cumberland County. Other counties where damages exceeded $100,000 were Burlington, Atlantic, and Salem.

Only 29 out of the seventy plant species that exhibited injury were involved in the assessment of crop loss. As a group, vegetables accounted for 51 percent ($598,099) of the total crop loss. Damage to

lettuce alone accounted for over one-third ($185,425) of the losses to the vegetable crop and for about 12 percent of the estimated total crop loss in New Jersey.

The photochemical pollutants were responsible for 80 percent of the plant injury recorded, with ozone contributing about 60 percent and PAN 20 percent of the total. The other pollutants involved and their percentages of plant injury are: HCl mist and chlorine gas 6 percent, ethylene 3 percent, fluoride 2 percent, sulfur dioxide 2 percent, ammonia 2 percent, particulates 2 percent, and oil, petroleum and an unidentified pollutant 3 percent.

Air pollution gardens were maintained in various areas of the state to aid the cooperators in noting time and classification of pollution damage.

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INTRODUCTION

New Jersey, perhaps the most urbanized state in the nation, has 1,035,678 acres of farm land; 496,241 acres of which are devoted to the production of food crops. The value of these crops sold in 1969 amounted to $124,254,021 accounting for more than 50 percent of the total farm marketings (1). New Jersey ranked 36 among the states in total cash crop receipts in 1970, and is considered a major state in the production of several important crops (1, 2). The rank of New Jersey in the production of selected crops is shown in Table 1. The total acreage and dollar value of important crops grown are shown in Table 2.

Although air pollution damage to crops has been known for more than a century, the problem did not become serious in New Jersey until the late years of World War II. Prior to this time air pollution damage in the state was believed to be limited to that produced by SO_2, illuminating gas and ethylene (5). However, expansion in industry and vehicular traffic, and new processes in connection with the war effort introduced new pollutants which created a serious threat to our highly valuable agricultural industry.

Air Poilution injury to crops in New Jersey was first observed in two locations along the Delaware River (5). In 1946 the State Legislature appropriated funds to the New Jersey Agricultural Experiment Station to make a study on the effect of industrial fumes on adjoining agricultural lands and their effect on plant and animal life in the State of New Jersey.

A research team from Rutgers University headed by Dr. Robert H. Daines was appointed to investigate this problem. They reported that foliage injury observed in cultivated crops, ornamentals and native vegetation could not be attributed to any known disease, nor to temperature or fertilizer effects. However, the similarity of injury on corn and peaches from cryolite, a fluoride-containing insecticide, and the presence of industrial establishments in the area that were actively engaged in the production and use of fluorine, implicated fluorine as the responsible pollutant. Since then this group of researchers has published valuable papers on the identification and relative levels of some air pollutants occurring in the atmosphere of New Jersey, plant species affected, and effects of climatic, nutritional, and biological factors affecting plant response to specific air pollutants. Other works have been published which have improved our knowledge of the basic aspects of pollutant absorption, translocation and their effects on the physiological activities of plants.

The advancing urbanization of the state no doubt poses increasing problems to agricultural production. If agriculture is to remain the means of livelihood for many people in New Jersey, the problems created by air pollution must be minimized. The first step toward realization of this goal is to determine the nature and extent of air pollution problems in New Jersey. With this information in hand, the necessary research, manpower and funds could be directed toward solving our most urgent problems. Thus, a statewide survey was initiated to obtain a realistic appraisal of air pollution damage to vegetation in New Jersey. This kind

of information is also needed to make more rational decisions about environmental matters where the trade-off between the costs and benefits of these decisions are important.

Table 1. RANK OF NEW JERSEY FOR SELECTED CROPS IN 1971

Crop	1	2	3	4	5
Late Summer potato production	Washington	Wisconsin	Colorado	New Jersey	California
Vegetables - Fresh Market Production					
Asparagus	California	New Jersey	Washington	Massachusetts	
Sweet Corn	Florida	California	New York	Ohio	New Jersey
Green Peppers	California	Florida	New Jersey	Texas	North Carolina
Spinach	Texas	California	New Jersey	Colorado	
Tomatoes	California	Florida	New Jersey	S. Carolina	Texas
Vegetables - Processing Production					
Asparagus	California	Washington	Michigan	New Jersey	Illinois
Tomatoes	California	Ohio	Indiana	New Jersey	Pennsylvania
Fruit and Berry Production					
Peaches	California	S. Carolina	New Jersey	Georgia	Pennsylvania
Blueberries	Michigan	New Jersey	N. Carolina	Washington	
Cranberries	Massachusetts	Wisconsin	New Jersey	Washington	Oregon
Strawberries	California	Florida	Michigan	Louisiana	New Jersey

Table 2.
ACREAGE AND DOLLAR VALUE OF SELECTED CROPS GROWN IN NEW JERSEY [1/]

Crops	Value (thousand dollars)	Acres
Apples	5,635	—
Asparagus	6,782	17,400
Barley	1,254	20,000
Blueberries	6,874	7,200
Broccoli	88	130
Cabbage	3,471	4,200
Carrots	481	1,000
Cherries	82,740 lb. [5/]	51
Corn (grain)	6,396	80,000
Cranberries	2,773 [3/]	3,100
Cucumbers, fresh market	1,301	1,600
Eggplant	1,548	1,500
Escarole	1,647	1,100
Forest Products	611	—
Grapes	238	—
Greenhouse & Nursery	34,997	—
Hay	12,798	137,000
Lettuce	3,049	3,400
Muskmelon	—	—
Oats	292	7,000
Onions	1,864	1,800
Peaches	10,625	—

Table 2. (Continued)

Crops	Value (thousand dollars)	Acres
Pears	275,702 lb. 5/	90
Peppers	3,617	8,100
Potatoes, Irish	6,738	11,000
Raspberries	—	—
Rye	263	10,000
Snap beans, fresh market	2,499	5,000
Sorghum	6,366 bu. 5/	125
Soybean (Beans)	3,998	51,000
Spinach, fresh market	924	1,400
Sweet Corn	4,134	11,100
Sweetpotatoes	1,408	1,300
Strawberries	2,268	1,700
Tomatoes	18,135	20,900
Wheat	2,202	33,000
Other Processing Veg.	5,041 2/	18,720
Miscellaneous fresh market vegetable	5,062 4/	—

Christmas Trees - Included in forest products

Vegetables under glass

1/ Figures obtained from the office of New Jersey Crop Reporting Service, Trenton, N.J. 08625

2/ Includes snap beans, lima beans, beets, cucumbers for pickles, green peas and spinach.

3/ Value based on 1971 price.

4/ Includes greenhouse tomatoes.

5/ Production only. No value available.

THE SURVEY

Surveys concerned with air pollution injury to vegetation and its economic impact on agriculture have been conducted for several years in California and for three years or more in Pennsylvania. At the present time, New England and New Jersey are involved in similar projects.

In 1969 Millecan (10) estimated that California growers suffered a 44.5 million dollar loss as a result of air pollution injury. This figure did not include losses to forest or ornamental plantings. Lacasse and Weidensaul (7) estimated an $11.5 million loss to Pennsylvania growers as a result of direct and indirect injury from air pollution. Figures for 1970 show a $25.6 million loss in California (11) and a $225 thousand loss in Pennsylvania.

Workers in New Jersey have long recognized the economic impact of air pollution on agriculture in this state (4,5,9). Although an extimate of crop loss due to air pollution in the amount of $832,700 to commercial crops has been reported by Stanford Research Institute (3), there has been no actual field survey undertaken in New Jersey.

The present survey was designed to assist in making an estimate of the economic losses resulting from air pollution damage to outdoor and greenhouse crops in New Jersey. This survey was financed by the Office of Research and Monitoring, Environmental Protection Agency, from April 1971 to January, 1972, and by the New Jersey Department of Agriculture, Division of Rural Resources from February, 1972 to April, 1972. The survey was a cooperative effort between the Cooperative Extension Service and Department of Plant Biology of Rutgers-The State University. The

help of arborists, orchardists, nurserymen, florists, vegetable growers and gardeners was also solicited in reporting suspected air pollution injury to their plants. The author, a plant pathologist with three years experience on air pollution problems, was appointed survey leader to direct and coordinate the work with county agents and extension specialists to assess the crop loss.

A two-day training session to acquaint the participating county agents with the nature and effects of air pollution on vegetation was conducted. This program included slide-illustrated talks by nationally recognized air pollution experts. Printed information was distributed which served as guidelines for the evaluation of air pollution injury. In addition to the two-day training program, the county agents attended short courses and seminars conducted by the Department of Plant Biology on recognition of air pollution damage to fruits, vegetables and ornamental crops.

The Department of Meteorology submitted timely warnings regarding meteorological conditions conducive to possible air pollution damage incidents. The project leader then passed the information to county agents who were on the lookout for possible air pollution episodes. Once an air pollution episode was recognized, the county agent filled out the inquiry report card, modified from the Pennsylvania 1969 report card (6) (Figure 1), and mailed it to our office or informed the project leader directly by telephone. The project leader visited the area with the county agent, identified the pollutant involved whenever possible, and brought specimens to the laboratory for further diagnosis and verification. A thorough documentation of the incident was made by direct field investigation and by consulting with the growers, with

AIR POLLUTION INJURY REPORT

Location _____

Name of grower _____

Date of injury _____

Name of crop (species and variety) _____

Acreage damaged _____ or no. of plants damaged _____

% of total no. damaged _____

% of each plant damaged _____

Loss in (check one): Quality _____ Quantity _____

Estimated loss _____% or $ _____

Suspected pollutant _____Suspected source _____

Remarks _____

_____

_____

Date filed _____Reporter's name _____

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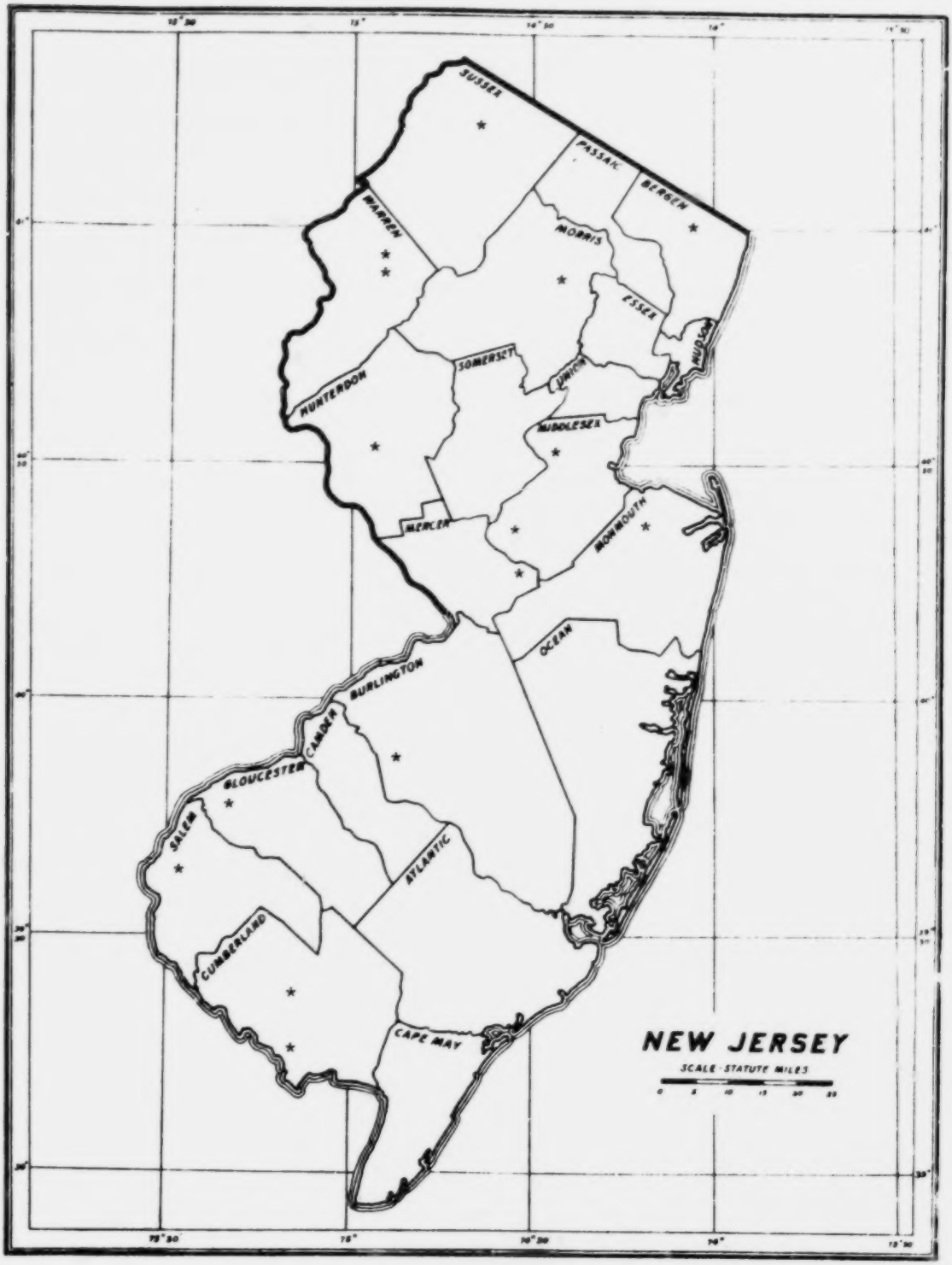
special emphasis on collection of information pertinent to assessment of crop loss. When applicable, chemical tissue analyses were conducted in the laboratory for pollutant residues. Tissue analyses were considered useful in confirming plant damage caused by fluoride, HCl mist or Cl_2 gas and SO_2. The project leader and the county agent revisited many affected fields throughout the season to provide a more accurate assessment of crop loss. Furthermore, to ensure that most of the air pollution incidences were documented, a regular appointment with each county agent was arranged in order to visit as many farms, nurseries and greenhouses as could be covered during the visit in their respective counties.

A garden containing the plants sensitive to air pollution injury was established in approximately fifteen agricultural areas throughout the state (Figure 2). The locations listed below cover the most important areas.

a.	Plainsboro	f.	Salem	k.	Pinebrook
b.	Evesboro	g.	Swedesboro	l.	Holmdel
c.	Cedarville	h.	Hightstown	m.	Sussex
d.	Centerton	i.	Flemington	n.	New Brunswick
e.	Great Meadows	j.	Hackettstown	o.	Paramus

The plant indicators used were as follows:

1. Ozone (O_3) - Pinto Beans and Tobacco var. Bel W_3
2. Sulfur Dioxide (SO_2) - Squash and Begonia var. Viva and Pink Tausendschon
3. Peroxyacetyl Nitrate (PAN) - Swiss Chard and Petunia var. White Sails
4. Fluoride (F) - Gladiolus var. White Friendship and Beverly Ann


SUSSEX
PASSAIC
BERGEN
WARREN
MORRIS
ESSEX
HUDSON
SOMERSET
UNION
HUNTERDON
MIDDLESEX
MERCER
MONMOUTH
OCEAN
BURLINGTON
CAMDEN
GLOUCESTER
SALEM
ATLANTIC
CUMBERLAND
CAPE MAY
NEW JERSEY
SCALE - STATUTE MILES

These "air pollution gardens," as we commonly call them, were designed to aid the cooperators in noting time, and classification of pollution damage. It also served as a valuable educational tool in maintaining the interest of cooperators.

Pinto bean and tobacco variety Bel W_3 were excellent indicators of ozone and PAN incidences. In one garden located in Bergen County, the agricultural county agents recorded plant injury on 8 separate dates from June 17 to September 5, 1971. Most of the plant injury was observed from 48 to 72 hours after a period of weather stagnation.

Petunia and begonia although sensitive to PAN and SO_2, respectively, become less susceptible to the pollutants under field conditions especially during the latter part of the growing season.

ASSESSMENT OF LOSS

Field observations provided the main source of data used in the assessment of crop loss. The number of field observations made was in turn dependent on the number of pollution incidences reported by the agricultural county agents, extension specialists, growers and other cooperators.

Methods of assessing loss as a result of air pollution varied. No specific methods could be adequately applied to all situations. In cases where the entire crop planting was rendered unmarketable, total loss was based on the crop value of the acreage affected. Data on the calculation of the harvest value of the crop and price of the commodities were obtained from the Office of New Jersey Crop Reporting Service at Trenton, New Jersey. However, when available, local crop values rather than the state averages were used in assessing crop loss. If crop damage was not complete, the loss reported reflected only that portion of the crop affected, e.g. reduction in yield or quality, increased labor cost due to removal of damaged parts, etc. In cases where no direct correlation existed between production losses and the amounts of leaf injury, a "rule of thumb" evaluation method was used for estimating loss. Where visual inspection of the overall leaf surface of the plants indicated 1 to 5 percent injury, a 1 percent loss was applied for that crop. A leaf surface injury ranging from 6 to 10 percent was given a 2 percent loss; 11 to 15 percent injury, a 4 percent loss; and 16 to 20 percent injury an 8 percent loss (11).

Assessment of loss resulting from destruction of aesthetic value, grower relocation cost, farm abandonment and other indirect effects as a result of air pollution injury was not made. Many incidences of photochemical injury to our forest and shade trees and to other crops, specifically eggplant and corn, during this 1971 survey were investigated. The lack of a suitable assessment procedure precluded any attempt to place a loss assessment in these instances. Furthermore, reduction in yield and/or quality of the crop resulting from "hidden injury" due to air pollution is not within the scope of this survey.

RESULTS

Economic Losses. The results of the survey were based primarily upon actual field observations made by the survey leader in cooperation with the farmers and the agricultural county agents from April 1971 to April 1972. The survey leader analyzed and interpreted the data and assumed responsibility for the interpretations contained within this report.

During this survey, which is in its first year, economic losses to crops in New Jersey due to air pollution amounted to $1,183,800 (Table 3). This amount represents only direct losses. Indirect losses such as grower's relocation cost, crop substitution losses, loss in value of the land, etc., were not included.

The 315 reports of air pollution damage were confirmed during the period of the survey (Table 7). Three hundred and one incidences were attributed to 8 pollutants: ozone, PAN, (peroxyacetyl nitrate), HCl mist and Cl_2 gas, ethylene, sulfur dioxide, ammonia, fluoride and particulates. The other 14 incidences were attributed to petroleum oil and herbicide injuries, and to an unidentified pollutant. Analysis of the data (Table 7) showed that 80 percent of the damage was caused by pollutants resulting from photochemical reactions, with ozone contributing 57 percent and PAN 23 percent of this total. Hydrochloric acid mist and chlorine gas injury, which resulted from accidental spillage from a nearby source accounted for 6 percent of the damage. Ethylene plant injury (3 percent) was essentially associated with indoor crops grown in heated glasshouses. Plant injury from fluoride (2 percent) was very localized, occurring most frequently in areas near glass factories.

Sulfur dioxide, responsible for 2 percent of the total damage was observed most frequently near industrial establishments. Accidental spillage of ammonia fron an ice plant that affected a variety of crops in the neighborhood accounted for 2 percent of the total injury attributed to air pollutants. Acid aerosols (particulates) settling on leaves, which caused small necrotic spots on the upper leaf surface, was responsible for 2 percent of the damage. Oil, petroleum and an unidentified pollutant accounted for 3 percent of the damage.

Economic loss to crops due to air pollution injury was observed in 16 counties, with Cumberland experiencing the heaviest loss ($337,265), followed by Burlington, Atlantic and Salem Counties, each with more than $100,000 loss (Table 3). The 16 counties listed in Table 3 represent the most important agricultural areas of the state.

Seventy plant species (Table 4) were observed to be affected by air pollutants during this period of the survey. Twenty-nine of these plant species were involved in the assessment of crop loss.

As a group, vegetables experienced the greatest damage with an assessed loss of $588,053. This figure represents about 51 percent of the total damage (Table 5). Damage to field crops was estimated to be $430,212. Nursery and cut-flower growers incurred a loss of $88,400. Grape, the only fruit crop represented in this survey accounted for a $67,089 loss due to air pollution. Lettuce (Iceberg, Boston and Romaine) sustained the greatest loss of any one commodity which amounted to $184, 425 for early fall and late spring crops.

Table 3.

SUMMARY OF COUNTIES SHOWING CROP LOSSES
DUE TO AIR POLLUTION, IN 1971

Cumberland		337,265
Burlington		150,764
Atlantic		122,439
Salem		122,280
Mercer		87,956
Monmouth		84,860
Gloucester		82,110
Middlesex		60,053
Bergen		50,490
Cape May		33,779
Warren		33,777
Morris		8,247
Camden		4,295
Somerset		3,760
Hunterdon		1,720
Ocean		95
	TOTAL	$ 1,183.800

Table 4.

LIST OF PLANTS AFFECTED BY AIR POLLUTANTS DURING THIS SURVEY

Plant	Pollutant
Alfalfa *Medicago sativa* L.	O_3
Apple *Malus* sp.	NH_3
Ash, white *Fraxinus americana* L.	Cl_2
Azalea *Rhododendron* sp.	Herbicide
Bean *Phaseolus vulgaris* L	O_3, PAN, Herbicide
Bean, lima *Phaeolus limensis* Macf.	O_3, Petroleum
Beet *Beta vulgaris* L.	Herbicide
Begonia *Begonia* spp.	SO_2
Cabbage *Brassica oleracea* L.	Particulate
Catalpa *Catalpa* sp.	Particulate
Catbriar *Smilax* sp.	Cl_2
Celery *Apium graveolens* L.	O_3, PAN
Chard, swiss *Beta vulgaris* var. *cicla* L	PAN, Particulate
Cherry *Prunus avium* L	NH_3
Chrysanthemum *Chrysanthemum* sp.	Herbicide
Clover *Trifolium* spp	O_3
Corn *Zea mays* L.	O_3, Particulate
Cucumber *Cucumis sativus*	O_3
Cyclamen *Cyclamen* Sp.	O_3
Dandelion *Taraxacum officinale* Weber	PAN
Dogwood *Cornus florida* L.	Cl_2
Eggplant *Solanum melongena* L.	PAN
Elm *Ulmus americana* L.	Cl_2
Endive *Chichorium endivia* L.	O_3, PAN, HCl
Fir, Douglas *Pseudotsuga taxifolia* Bridt.	Cl_2
Gladiolus *Gladiolus* sp.	F
Gooseberry *Ribes* sp	Herbicide
Gourd *Luffa acutangula* L.	O_3
Grape *Vitis vinifera* L.	O_3, NH_3, Herbicide

Table 4. (Continued)

Plant	Pollutant
Hazelnut *Corylus americana* Walt.	Cl_2
Horsechestnut *Aesculus* sp.	NH_3
Iris *Iris* sp.	Cl_2, Herbicide
Ivy, English *Hedera helix* L.	Cl_2
Kohlrabi *Brassica caulorapa* Pasq.	Herbicide
Lamb's Quarter *Chenopodium album* L.	O_3
Leek *Allium porrum* L.	O_3
Lettuce *Lactuca* spp.	PAN, O_3, Herbicide, Oil
Lilac *Syringa vulgaris* L.	Cl_2
Lily, *Hosta*, sp.	Cl_2
Maple, sugar *Acer saccharum* Marsh.	Cl_2
Mulberry *Morus* sp.	Cl_2
Muskmelon *Cucumis melo* L.	O_3
Mustard *Brassica* sp.	PAN
Oak *Quercus* sp.	Cl_2
Oat *Avena sativa* L.	O_3
Onion *Allium cepa* L.	O_3, NH_3
Orchid *Cattleya* sp. *Phalaenopsis* sp.	E E
Pea *Lathyrus* spp.	O_3
Peach *Prunus persica* Sieb & Zucc.	Particulate
Pear *Pyrus* sp.	NH_3
Petunia *Petunia hybrida* Vilm	O_3, PAN
Pigweed *Amaranthus* sp.	O_3
Pine, Scotch *Pinus sylvestris* L.	Cl_2
Pine, white *Pinus strobus* L.	O_3
Plum *Prunus* sp.	NH_3
Potato *Solanum tuberosum* L.	PAN, O_3
Pumpkin *Cucurbita pepo* L.	O_3
Radish *Rhaphanus sativus* L.	O_3, PAN

Table 4. (continued)

Plant	Pollutant
Rose *Rosa* spp	Herbicide
Sorrel *Rumex acetosa* L.	PAN
Soybean *Glycine max* Merr	O_3
Spinach *Spinacia oleracea* L.	O_3
Squash *Cucurbita* spp.	O_3
Sunflower, Common *Helianthus annuus* L.	O_3
Sycamore *Platanus* sp.	O_3
Tomato *Lycopersicon esculentum* Mill	O_3, PAN, NH_3, Herbicide
Tulip, Darwin *Tulipa gesneriana* var. *darwinia* Bailey	SO_2
Tulip tree *Liriodendron tulipifera*	Cl_2
Turnip *Brassica rapa* L.	PAN
Watermelon *Citrullus vulgaris* Schrad.	O_3

Table 4. (Continued)

Plant	Pollutant
Soybean *Glycine mas* Merr.	O_3
Spinach *Spinacia oleracea* L.	O_3
Squash *Cucurbita* spp.	O_3
Sunflower, Common *Helianthus annuus* L.	O_3
Sycamore *Platanus* sp.	O_3
Tomato *Lycopersicon esculentum* Mill	O_3, PAN, NH_3, Herbicide
Tulip, Darwin *Tulipa gesneriana* var. darwinia Bailey	SO_2
Tulip tree *Liriodendron tulopifera*	Cl_2
Turnip *Brassica rapa* L.	PAN
Watermelon *Citrullus vulgaris* Schrad.	O_3

DISCUSSION AND RECOMMENDATIONS

The state of New Jersey has a total of 21 counties (Figure 2), however, data from only 16 counties were involved in the assessment of crop losses due to air pollution. The absence of air pollution damage to crops in the four remaining counties—Sussex, Essex, Hudson and Union—does not imply that these counties are "pollution-free," but rather, incidences in these areas were either not serious enough to realize economic loss or were simply overlooked and not reported at all. The survey was concentrated in the central and southern counties where most of the important agricultural crops such as fruits and vegetables are grown.

The cooperation of agricultural county agents and farmers made this initial survey possible. The county agents travel constantly in rural areas and growers call upon them for any problems that arise. County agents are extremely busy, however, especially during the growing season and would have little time to look specifically for air pollution damage. Most of the reported air pollution cases are brought to the attention of the county agents by the growers. Minor injuries, causing no noticeable damage to the plants would therefore easily go undetected.

This serious drawback was realized during the first few months of the survey. To alleviate this problem the project leader arranged for regular visits with each county agent to inspect as many farms, orchards, nurseries and greenhouses in his county as possible. This approach kept us in constant association with the farmers and enabled us to get firsthand knowledge of crop development. This procedure also gave me the opportunity

to demonstrate and explain to county agents and growers what air pollution injury looks like and how it affects their crops. Air pollution gardens were most helpful in this respect.

As a result of this approach many air pollution injuries to crops were observed and documented which would otherwise have gone unnoticed and not reported. These regular visits however were only possible because of the size of New Jersey. Since the success of the project depends on recognition of the injury by the farmers or the county agents, a continuing program aimed at educating the people concerned through demonstration and conferences should be pursued as often as possible.

The establishment of "air pollution gardens" will be continued during the 1972 survey. However, gardens will be limited to counties that expressed interest in maintaining them. Maintenance of the gardens posed a problem to the already overloaded schedule of the cooperators, and therefore, their establishment will not be imposed. In addition to the outdoor gardens, plant indicators will be established in greenhouses this year.

During the survey, instances of air pollution injury to landscape plantings and native vegetation were likewise noted but no attempt was made to tag a dollar value to this type of injury. There was also no basis for judging any small degree of reduced growth and reproduction (damage without visual symptoms of injury) due to air pollutants, which undoubtedly occurred. More research work is necessary to explore the relationship between air pollutants and growth suppression before any meaningful correlation can be made. Furthermore, there is an acute awareness that

photochemical pollutants (specifically ozone and PAN) account for the greater portion of the damage to crops in New Jersey. Whereas monitoring for ozone is a continuing practice, our knowledge of PAN formation and accumulation in the atmosphere of New Jersey is practically nil.

In many instances an unidentified pollutant causing foliar injury on Irish potato and tomato has been observed. The symptoms appear as numerous spots on the lower surface of the leaves with a characteristic bronze color. The symptoms were first observed two to three days after a period of weather stagnation. In one instance, tomato plantings (variety Supersonic and Jetstar) were injured at flowering. The flowers dropped off and the upper stems became woody prematurely resulting in a 40 percent reduction in yield. The importance of research along these lines can not be overemphasized.

Greenhouse problems were mainly due to faulty burners that failed to burn fuel properly, improper ventilation and use of poor grades of fuel. Timely diagnosis and appropriate actions for control often minimized crop losses in cases where the damage was not too severe.

Table 5.

SUMMARY OF 1971 CROP LOSSES IN NEW JERSEY
DUE TO AIR POLLUTION

Crop	Acreage Affected (acres)	Harvest Value*** (dollars)	Amount of Loss
FIELD			
Alfalfa	12,590	**	111,882
Clover	10,305	**	86,49
Potato	1,725	1,210,950	86,004
Soybean	22,509	1,553,121	145,827
	47,129	2,764,071	430,212
FRUIT			
Grape	264	229,337	57,089
NURSERY AND CUT FLOWERS			
Gladiolus	383	1,916,532	36,540
Ivy	6,000*	**	1,360
Orchid	80,000*	**	50,000
Miscellaneous	1	**	500
	383 86,000*	1,916,532	88,400
VEGETABLE			
Bean, bush, pole, snap	4,158	1,975,050	71,105
Bean, Lima	4,136	827,200	74,754
Cabbage	1	878	311
Chard	21	15,792	1,322
Cucumber	2,035	1,843,710	36,890

Table 5. (Continued)

Crop	Acreage Affected	Harvest Value***	Amount of Loss
	acres	dollars	
Vegetable (Continued)			
Dandelion	9	14,328	4,629
Endive and Escarole	427	565,775	52,146
Gourd	7	**	650
Leek and Green Onion	151	**	8,138
Lettuce	618	500,142	185,425
Muskmelon	375	366,375	3,252
Mustard	13	7,800	905
Onion, Dry	1,800	1,668,600	9,353
Pumpkin	531	531,000	5,616
Spinach	20	11,600	76
Sorrel	2	2,000	300
Squash	103	93,524	2,365
Tomato			
Fresh Market	672	667,270	64,255
Processing	1,993	1,600,379	67,427
Tomato	24,480*	**	7,830
Watermelon	254	36,322	850
Miscellaneous	1,125*		200
	17,326 25,605*	10,727,745	598,099
TOTALS	65,102 111,605*	15,637,685	1,183,754

* Greenhouse in square feet
** Harvest value not available
*** New Jersey Crop Reporting Service

Table 6.

COUNTY CROP LOSSES

County and Crop	Acreage Affected	Harvest Value	Amount of Loss
	acres	dollars	
ATLANTIC			
Field			
Potato	200	140,400	17,896
Fruit			
Grape	191	165,462	53,404
Vegetable			
Beans, bush, pole, snap	156	74,100	2,388
Cucumber	403	365,118	7,302
Endive and Escarole	50	66,250	4,00
Leek and Green Onion	39	**	2,148
Lettuce	51	40,287	18,197
Muskmelon	53	51,781	460
Pumpkin	21	21,000	214
Tomato			
Fresh market	205	195,365	10,907
Processing	293	235,279	5,353
Watermelon	49	7,007	170
TOTALS	1,711	1,362,049	122,439
BERGEN			
Nursery and Cutflowers			
Orchids	80,000*	**	50,000
Tulip	0.2	**	400
TOTALS			50,400

Table 6. (Continued)

County and Crop	Acreage Affected	Harvest Value	Amount of Loss
	acres	dollars	
BURLINGTON			
Field			
Alfalfa	5,000	**	62,000
Clover	3,000	**	37,200
Soybean	3,056	210,864	21,392
Fruit			
Grape	42	36,750	6,615
Vegetable			
Beans, bush, pole, snap	360	171,000	18,204
Pumpkin	16	16,000	163
Tomato	12,930*	**	5,050
Watermelon	28	4,004	140
TOTALS	11,502	438,618	150,764
CAMDEN			
Fruit	18		
Grape		15,750	4,295
CAPE MAY			
Vegetable			
Beans, bush, pole, snap	50	23,750	1,445
Beans, lima	1,965	393,000	32,334
TOTAL	2,015	416,750	33,779

Table 6. (Continued)

County and Crop	Acreage Affected (Acres)	Harvest Value (dollars)	Amount of Loss (dollars)
CUMBERLAND			
Field			
Potato	572	401,544	42,038
Soybean	1,065	73,485	12,455
Nursery and Cut Flowers			
Gladiolus	256	1,281,024	24,390
Vegetable			
Bean, bush, pole, snap	2,305	1,094,875	20,514
Bean, lima	1,524	304,800	28,480
Chard	5	3,760	250
Cucumber	800	724,800	14,496
Dandelion	3	4,776	148
Endive and Escarole	100	132,500	4,000
Leek and Green Onion	112	**	5,990
Lettuce, Romaine and Iceberg (late spring and early fall)	530	420,820	146,205
Lettuce, Romaine	1,125*	**	200
Muskmelon	123	120,171	1,065
Mustard	10	6,000	410
Onion, Dry	1,350	1,251,450	4,561
Sorrel	2	2,000	300
Tomato			
Fresh Market	53	50,509	15,573
Processing	347	278,641	15,645
Tomato	2,700	**	405
Watermelon	109	15,587	140
TOTAL	9,266	6,166,742	337,265

Table 6. (Continued)

County and Crop	Acreage Affected	Harvest Value	Amount of Loss
	acres	dollars	
GLOUCESTER			
Field			
Soybean	709	48,921	4,963
Nursery and Cut Flowers			
Gladiolus	127	635,508	12,150
Vegetable			
Beans, bush, pole, snap	110	52,250	1,979
Chard	1	752	70
Cucumber	305	276,330	5,527
Lettuce	10	10,010	5,870
Muskmelon	30	29,310	260
Onion, Dry	250	231,750	1,965
Pumpkin	300	300,000	3,060
Tomato			
Fresh Market	246	234,438	14,689
Processing	1,108	889,724	30,527
Tomato	2,250*	**	1,050
TOTAL	3,196	2,708,993	82,110
HUNTERDON			
Field			
Soybean	40	2,760	1,720
MERCER			
Field			
Alfalfa	890	**	12,497
Clover	2,000	**	23,600
Soybean	5,765	397,785	40,355

Table 6. (Continued)

County and Crop	Acreage Affected (acres)	Harvest Value (dollars)	Amount of Loss (dollars)
(Mercer Continued)			
Vegetable			
Tomato	2	28,760	11,504
TOTAL	8,657	426, 545	87,956
MIDDLESEX			
Field			
Alfalfa	500	**	13,800
Clover	700	**	3,260
Potato	300	210,600	7,390
Soybean	2,158	148,902	23,306
Vegetable			
Bean, bush, pole, snap	27	12,825	340
Bean, Lima	40	8,000	1,800
Chard	10	7,520	282
Cucumber	4	3,624	72
Endive and Escarole	10	13,250	400
Dandelion	6	9,552	4,481
Lettuce	4	4,004	2,348
Mustard	3	1,800	495
Pumpkin	14	14,000	243
Spinach	20	11,600	76
Nursery and Cut Flowers			
Ivy	6,000*	**	1,360
Roses	0.3	**	100
TOTAL	3,796	445,677	60,053

Table 6. (Continued)

County and Crop	Acreage Affected	Harvest Value	Amount of Loss
	acres	dollars	
MONMOUTH			
Field			
Alfalfa	2,000	**	12,600
Clover	1,500	**	6,700
Potato	630	442,260	15,545
Soybean	7,246	499,974	24,346
Fruit			
Grape	13	11,375	2,775
Vegetable			
Bean, bush, pole, snap	150	71,250	7,335
Cucumber	23	20,838	433
Endive and Escarole	64	84,800	9,200
Gourd	7	**	650
Lettuce	6	6,006	3,522
Pumpkin	105	105,000	1,071
Muskmelon	47	45,919	408
Watermelon	54	7,722	275
TOTAL	11,845	1,295,144	84,860
MORRIS			
Vegetable			
Endive and Escarole	50	66,250	6,700
Pumpkin	12	12,000	222
Tomato	6,600*	**	1,325
TOTAL	62	78,250	8,247

Table 6. (Continued)

County and Crop	Acreage Affected	Harvest Value	Amount of Loss
	acres	dollars	
OCEAN			
Vegetables			
Tomato (fresh market)	10	9,530	95
SALEM			
Field			
Alfalfa	3,000	**	8,275
Clover	2,605	**	14,689
Potato	23	16,146	3,135
Soybean	2,470	170,430	17,290
Vegetable			
Bean, bush, pole, snap	1,000	475,000	18,900
Bean, Lima	607	121,400	12,140
Cucumber	500	453,000	9,060
Lettuce	15	15,015	5,283
Muskmelon	122	119,194	1,059
Onion, Dry	100	92,700	1,927
Pumpkin	63	63,000	643
Squash	103	93,524	2,365
Tomato			
Fresh Market	156	148,668	11,487
Processing	245	196,735	15,902
Watermelon	14	2,002	125
TOTAL	11,023	1,966,814	122,280

Table 6. (Continued)

County and Crop	Acreage Affected	Harvest Value	Amount of Loss
	acres	dollars	
SOMERSET			
Field			
Alfalfa	1,200	**	2,710
Clover	500	**	1,050
TOTAL	1,700		3,760
WARREN			
Vegetable			
Cabbage	1	878	311
Chard	5	3,760	720
Endive and Escarole	153	202,725	27,846
Lettuce	4	4,000	4,000
Onion, Dry	100	92,700	900
TOTAL	261	304,063	33,777
GRAND TOTAL	65,102	15,637,685	1,183,754

* Greenhouse in square feet.
** Harvest value not available.

Table 7.

SUMMARY OF PLANT INJURY REPORT BY COUNTIES

County and Crop	Pollutant [1/]	Number of Reports
ATLANTIC		
Field		
Potato	O_3	2
	PAN	1
Fruit		
Grape	O_3	2
Vegetable		
Bean	O_3	1
Cucumber	O_3	3
Endive and Escarole	Pan	2
	O_3	1
Leek and Green Onion	O_3	2
Lettuce	Pan	3
Muskmelon	O_3	1
Pumpkin	O_3	2
Tomato	O_3	3
	Pan	2
Watermelon	O_3	1
		26
BERGEN		
Floral and Weed Crop		
Catbriar	Cl_2	1
Dogwood	Cl_2	1
Iris	Cl_2	1
Lily	Cl_2	1
Lilac	Cl_2	1

Table 7. (Continued)

County and Crop	Pollutant[1/]	Number of Reports
Bergen (Continued)		
Petunia	PAN	1
Orchid	E	7
Tulip	SO_2	1
Forest and Shade Trees		
Ash	Cl_2	1
Elm	Cl_2	1
Fir	Cl_2	1
Hazel nut	Cl_2	1
Maple	Cl_2	1
Mulberry	Cl_2	1
Oak	Cl_2	1
Pine	Cl_2	1
Tuliptree	Cl_2	1
		23
BURLINGTON		
Field		
Alfalfa	O_3	4
Clover	O_3	4
Soybean	O_3	3
Fruit		
Grape	O_3	1
Vegetables		
Beans	O_3	2
Pumpkin	O_3	2
Tomato	O_3	1
	SO_2	2
Watermelon	O_3	1
		20

Table 7. (Continued)

County and Crop	Pollutant 1/	Number of Reports
CAMDEN		
Fruit		
Grape	O_3	1
CAPE MAY		
Vegetable		
Beans	O_3	5
	Pet	1
		6
CUMBERLAND		
Field		
Potato	O_3	3
	PAN	4
Soybean	O_3	2
Vegetable		
Bean	O_3	3
Chard	PAN	1
Cucumber	O_3	2
Dandelion	PAN	1
Eggplant	PAN	5
Endive and Escarole	PAN	1
Leek and Green Onion	O_3	3
Lettuce	PAN	2
	O_3	2
	Oil	1
Muskmelon	O_3	1
Mustard	PAN	1
Onion, Dry	O_3	2
Radish	O_3	1
Sorrel	PAN	2
Tomato	O_3	5
	PAN	3
	SO_2	2

Table 7. (Continued)

County and Crop	Pollutant 1/	Number of Reports
Cumberland (Continued)		
Vegetables		
Turnip	PAN	1
Watermelon	O_3	1
Nursery and Cut Flowers		
Gladiolus	F	2
		51
GLOUCESTER		
Field		
Soybean	O_3	4
Nursery and Cut Flowers		
Gladiolus	F	3
Vegetable		
Bean	O_3	2
Chard	PAN	1
Cucumber	O_3	3
Lettuce	PAN	1
Muskmelon	O_3	1
Pumpkin	O_3	1
Tomato	O_3	2
	PAN	2
		20
HUNTERDON		
Field		
Soybean	H	1
MERCER		
Field		
Alfalfa	O_3	2
Clover	O_3	2
Soybean	O_3	3
	PAN	1
Vegetable		
Tomato	PAN	1
	U	1
	38	10

Table 7. (Continued)

County and Crop	Pollutant	Number of Reports
MIDDLESEX		
Field		
Alfalfa	O_3	3
Clover	O_3	3
Oat	O_3	1
Potato	PAN	1
	O_3	1
Soybean	O_3	3
Floral and Weed Crop		
Azalea	H	1
Begonia	SO_2	2
Chrysanthemum	H	1
Iris	H	1
Ivy	Cl	1
Lamb's Quarter	O_3	2
Petunia	O_3	3
Pigweed	O_3	1
Rose	H	1
Sunflower	O_3	1
Sycamore	O_3	2
Forest and Shade		
Pine	O_3	2
Chestnut	NH_3	1
Fruit		
Apple	NH_3	1
Cherry	NH_3	1
Gooseberry	H	1
Grape	NH_3	1
	H	1
Pear	NH_3	1
Plum	NH_3	1

Table 7. (Continued)

County and Crop	Pollutant[1/]	Number of Reports
Middlesex (continued)		
Vegetable		
Bean	H	1
	O_3	1
Beet	H	1
Chard	P	1
	PAN	1
Cucumber	O_3	1
Endive and Escarole	PAN	2
Dandelion	PAN	1
Kohlrabi	H	1
Lettuce	H	1
	PAN	2
Mustard	PAN	1
Pumpkin	O_3	1
Spinach	O_3	2
		55
MONMOUTH		
Field		
Alfalfa	O_3	2
Clover	O_3	1
Potato	O_3	1
	PAN	3
Soybean	O_3	4
Fruit		
Grape	O_3	1
Vegetable		
Bean	O_3	2
Cucumber	O_3	2
Endive and Escarole	PAN	3
Gourd	O_3	1
Lettuce	PAN	2

Table 7. (Continued)

County and Crop	Pollutant[1/]	Number of Reports
Monmouth (continued)		
Vegetable		
Pumpkin	O_3	3
Muskmelon	O_3	2
Watermelon	O_3	1
		28
MORRIS		
Vegetables		
Endive and Escarole	PAN	2
Pumpkin	O_3	1
Tomato	E	1
Floral and Weed Crop		
Cyclamen	O_3	1
		5
OCEAN		
Vegetable		
Tomato	PAN	1
PASSAIC		
Field		
Corn	P	1
Fruit		
Peach	P	1
Forest and Shade		
Catalpa	P	1
		3
SALEM		
Field		
Alfalfa	O_3	2
Clover	O_3	3
Potato	PAN	1
	O_3	2
Soybean	O_3	3

Table 7. (Continued)

County and Crop	Pollutant 1/	Number of Reports
Salem (continued)		
Vegetable		
Bean	PAN	3
	O_3	4
Celery	PAN	1
	O_3	1
Cucumber	O_3	3
Lettuce	PAN	2
Muskmelon	O_3	4
Onion, Dry	O_3	2
Pumpkin	O_3	3
Squash	O_3	4
Tomato	PAN	4
	O_3	2
Watermelon	O_3	1
		45
SOMERSET		
Field		
Alfalfa	O_3	2
Clover	O_3	2
		4
WARREN		
Vegetable		
Cabbage	P	1
Chard	PAN	1
Endive and Escarole	PAN	4
	HCl	3
	O_3	2
Lettuce	PAN	3
Onion, Dry	O_3	2
		16
	GRAND TOTAL	315

1/ Cl_2 = Chlorine gas
E = Ethylene
F = Fluoride
H = Herbicide
NH_3 = Ammonia
O_3 = Ozone
PAN = Peroxyacetyl nitrate
P = Particulate
Pet = Petroleum
SO_2 = Sulfur Dioxide
U = Unidentified pollutant

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